

INDOOR AIR QUALITY ASSESSMENT

**Muddy Brook Regional Elementary School
318 Monument Valley Rd
Great Barrington, Massachusetts**



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
May 2006

Background/Introduction

At the request of Steven Soule, Facilities Supervisor, Berkshire Hills Regional School District, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) conducted an evaluation of the indoor air quality at the Muddy Brook Regional Elementary School (MBRES), Monument Valley Road, Great Barrington, Massachusetts. On November 4, 2005, Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted this assessment. Mr. Feeney had previously examined the MBRES on July 29, 2005, in response to concerns of potential mold growth that may have resulted from excessively humid weather experienced during July 2005 (MDPH, 2005). The aim of the visit was to conduct a general indoor air quality evaluation while the building was fully occupied.

The MBRES is a newly constructed red brick building completed in 2005 and was first occupied in July 2005 prior to full completion of the project. The school contains general classrooms, special education rooms, computer room, library, the school nurse's office, cafeteria, kitchen, teachers' rooms, art room, music room, gymnasium and office space. Windows throughout the building are openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic

compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 370 students in pre-kindergarten through grade 4, with approximately 40 staff members. Tests were taken during normal operations at the school. Results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were less than 800 parts per million (ppm) in all but one of thirty-six areas, indicating adequate ventilation in the majority of areas surveyed. Please note however that a number of areas were not fully occupied. Low occupancy can greatly reduce carbon dioxide levels.

A heating, ventilation and air conditioning (HVAC) system provides ventilation to rooms throughout the school. Fresh air is provided by air handling units (AHUs) (Picture 1). These AHUs are connected to ducts that supply fresh air to rooms through ceiling mounted air diffusers. By design, air diffusers are equipped with fixed louvers,

which create airflow by directing the air supply along the ceiling to flow down the walls. Air is returned to AHUs by ductwork attached to ceiling and wall vents.

Local airflow to each diffuser is controlled by a variable air volume (VAV) box. Each VAV box has a set of thermostat-controlled dampers that open or close depending on the temperature demand for a serviced area. Once the thermostat detects that the temperature has reached a pre-determined level, the VAV box dampers close until heating or cooling is needed. VAV boxes also control the provision of fresh air to a serviced space. During times that the temperature of a space is adequate, the VAV box closes its damper and limits the amount of fresh air. If the thermostat calls for the HVAC system to provide heat, the AHU fresh air intake damper would close to increase the temperature of the air in the ductwork and occupied spaces. Airflow would be noted from the ceiling air diffusers because the VAV box dampers are open, but fresh air supply would be limited because the rooftop fresh air intake damper would be closed.

While it has the advantage of energy conservation and lower operating costs, VAV box systems may not provide for adequate fresh air supply. For example, once the temperature requirement is met, airflow drops. Airflow can drop to zero in poorly performing HVAC systems (Plog, Niland and Quinlan, 1996). Please note that this condition may occur during times of outdoor temperature extremes ($< 32^{\circ}\text{ F}$ or $>90^{\circ}\text{ F}$). Air monitoring was conducted on a day with comfortable outdoor conditions (68° F). To ascertain whether zero airflow conditions exist, air monitoring during temperature extremes should be considered.

Of note was a motorized exhaust vent located above a hallway display case, opposite the elevators (Picture 2). As is typical of this design, ductwork connects this

exhaust vent to the AHU. Rooms on the elevator side of the hallway have passive vents (Picture 3) that allow air to pass into the hallways and be drawn into the hallway vent; these rooms do not have mechanical exhaust vents within the room. The hallway vent does not provide adequate draw of air from classrooms with passive vents. The hallway exhaust vent does, however, draw air from the nearby elevator shaft.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The systems were reportedly balanced prior to occupation in 2005.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur,

leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see [Appendix A](#).

Temperature measurements ranged from 70° F to 74° F, which were within the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 30 to 40 percent for most areas, which was below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building are expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As previously discussed, MDPH staff previously assessed the building on July 29, 2005 for mold and water damage. During the initial assessment, odors were traced to instrument cases located in the music room. These instrument cases were replaced prior to the full assessment of the building. The moistened gypsum wallboard in the OP/TP room was not replaced as previously recommended; however, CEH staff found the area of the OP/PT room free of odors. Other recommendations concerning removal of gypsum wallboard in the OP/PT room and altering the landscaping outside the building had not yet occurred at the time of this assessment.

Plants were observed in several areas (Picture 4 and 5). In one classroom, a large plant was located on top of the carpet (Picture 5). Plants should have drip pans to prevent wetting and subsequent mold colonization. Plants, soil and drip pans can serve as sources of mold growth, and thus should be properly maintained. Plants should not be placed on carpeting or porous materials, as overflow in drip pans can result in mold growth in such materials. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less

(PM_{2.5}) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH staff obtained measurements for carbon monoxide and PM_{2.5}.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND. Carbon monoxide levels measured in the school were also ND (Table 1).

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. According to the NAAQS, PM₁₀ levels should not exceed 150 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM_{2.5} standard requires outdoor air particulate levels be maintained below $65 \mu\text{g}/\text{m}^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM₁₀ standard for evaluating air quality, MDPH uses the more protective PM_{2.5} standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM_{2.5} concentrations were measured at $12 \mu\text{g}/\text{m}^3$. PM_{2.5} levels measured indoors ranged from 7 to $18 \mu\text{g}/\text{m}^3$ (Table 1), which were below the NAAQS of $65 \mu\text{g}/\text{m}^3$. Frequently, indoor air levels of particulates (including PM_{2.5}) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and

microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC measurements throughout the building were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Of note were two areas that had distinctive odors. The elevator car and third floor hallway had a hydraulic fluid odor, which is an oily, irritating scent. Of note is the previously discussed return air vent in the hallway, which is located opposite the third floor elevator doors. The return vent appeared to be drawing air rapidly at the time of

assessment. This vent may have a significant role in the noted hydraulic fluid odor. The vent likely draws odors up the elevator shaft.

A strong, rubber/plastic odor was detected in the front foyer of the MBRES. The source of this odor appears to be floor mats on the floor of the foyer (Picture 6). The floor mats appear to consist of a plasticized rubber-like material. The front foyer is a metal/glass structure (Picture 7) that does not contain any mechanical ventilation. As the foyer warms through solar radiation, the temperature increases, which then accelerates off-gassing of odor from these mats. A return vent for the ventilation system is located above the reception desk. The vent will tend to draw the mat odor into the building when the foyer doors are open. The mat odor is an acrid, unpleasant odor which can be irritating to the nose and throat for some individuals.

Cleaning products were found on countertops and beneath sinks in a number of classrooms. Cleaning products contain VOCs and other chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Classrooms contained a number of conditions that may attract rodents and flies. A number of flies were observed in classrooms (Table 1). Re-used food storage containers were noted in some classrooms. An open bin filled with water and presumably green food coloring was also observed in a classroom. In addition, one classroom had student art projects that were made with food. Each of these circumstances can create conditions that attract pests. Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can

introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation. The reduction/elimination of pathways/food and water sources that are attracting these insects should be the first step taken to prevent or eliminate this infestation.

Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals can cause running nose or skin rashes in sensitive individuals (e.g., running nose or skin rashes). A three-step approach is necessary to eliminate rodent infestation:

1. Removing of the rodents;
2. Cleaning of waste products from the interior of the building; and
3. Reducing/eliminating pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, 1995). A combination of cleaning, along with an increase in ventilation and filtration should serve to reduce rodent associated allergens once the infestation is eliminated.

Of note was the presence of a lead-based pottery glaze in the art room. During the pottery firing process, lead fumes may emanate from kilns if such glazes are used. Lead exposure to women of reproductive age poses a number of risks to a developing fetus (ATSDR, 1999). Lead exposure, particularly in the early stages of pregnancy when the woman may not know that she is pregnant, may result in adverse effects from *in utero*

exposure to lead. Lead exposure in males has been associated with reduced fertility because of effects on sperm (ATSDR, 1999). It is highly recommended that the use of non-lead containing materials be substituted for lead-containing glazes/materials.

Accumulated items were observed in some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and desks. The materials stored in classrooms provide surfaces for dust to accumulate. Accumulation of these items makes cleaning difficult for custodial staff. Dust can be irritating to eyes, nose and respiratory tract.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made to improve general indoor air quality:

1. Continue to implement previous MDPH recommendations concerning water damage ([Appendix B](#)).
2. Examine the feasibility of installing ductwork to connect third floor rooms with passive vents to the AHUs to reduce hallway depressurization.
3. Examine the VAV box servicing rooms 210, 212 and 214 for proper function. Adjust the VAV box to introduce more fresh air.
4. Repair hydraulic fluid leak causing odor in the elevator shaft.
5. Remove rubberized mats from the foyer and allow to air out in an area outside the school. Contact the manufacturer for information on the most appropriate manner to remove odor from these mats, which may include cleaning with mats with soap and water, then thoroughly drying.

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Remove lead containing pottery glaze from the art room.
8. Store cleaning products properly and out of reach of students.
9. Use the principles of integrated pest management (IPM) to rid the building of pest. A copy of the IPM recommendations can be obtained from the Massachusetts Department of Food and Agriculture (MDFA):
http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
Activities that can be used to eliminate pest infestation may include the following activities:
 - a) Discontinue use of food as components in student artwork.
 - b) Rinse out recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
 - c) Remove non-food items that rodents could consume.
 - d) Store foods in tight fitting containers.
 - e) Refrain from having standing water in bins.

- f) Avoid eating at workstations. In areas where food is consumed, periodic vacuuming to remove crumbs are recommended.
 - g) Regularly clean crumbs and other food residues from ovens, toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment.
 - h) Examine each room and the exterior walls of the building for means of rodent egress and seal. Holes as small as 1/4" are enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents. Reduce harborages (cardboard boxes) where rodents may reside (MDFA, 1996).
10. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.
11. Refer to resource manuals and other related indoor air quality documents for additional building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

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Picture 1



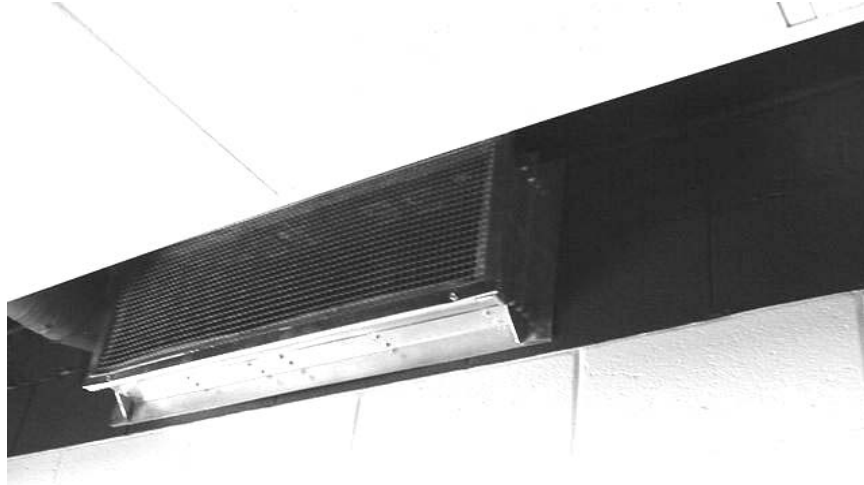
AHUs

Picture 2



Exhaust Vent in the Hallway opposite the Elevators

Picture 3



Passive Vents in Hallway opposite the Return Vent In Picture 2

Picture 4



Plants in Classroom

Picture 5



Plants in Classroom

Picture 6



Foyer Carpet

Picture 7



Front Foyer, Exterior Shot

Muddy Brook Regional Elementary School
Monument Valley Road, Great Barrington, MA

Indoor Air Results
Date: 11/4/2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	351	68	31	367	ND	ND	12	N			
cafeteria	504	72	34	696	ND	ND	18	N	Y wall	Y wall	Hallway DO,
elevator	0	73	33	404	ND	ND	16	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO,
Library	4	72	30	480	ND	ND	5	Y # open: 0 # total: 0	Y ceiling	Y ceiling	pests, plants, passive vent.
3rd floor hallway	0	73	33	499	ND	ND	4	N	Y ceiling	Y ceiling	hydraulic fluid odor.
103	14	71	31	543	ND	ND	10	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM, dehumidifier.
104	0	70	32	418	ND	ND	8	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO,

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

VL = vent location

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1-1

Muddy Brook Regional Elementary School
Monument Valley Road, Great Barrington, MA

Table 1

Indoor Air Results
Date: 11/4/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
106	2	70	32	433	ND	ND	9	Y # open: 0 # total: 2	Y ceiling	Y ceiling	DEM, spaces around exterior door .
108	0	70	32	386	ND	ND	7	Y # open: 0 # total: 2	Y ceiling	Y ceiling	aqua/terra, cleaners, pets, plants, sand box water table.
109	19	71	32	598	ND	ND	9	Y # open: 0 # total: 2	Y ceiling	Y ceiling	DEM, pets.
110	15	71	35	561	ND	ND	16	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Exterior DO, plants, food as art.
111	0	70	33	389	ND	ND	9	Y # open: 0 # total: 2	Y ceiling	Y ceiling	DEM, nests, pets.
202	2	73	32	492	ND	ND	10	Y # open: 1 # total: 1	Y ceiling	Y ceiling	Hallway DO,

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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1-2

Muddy Brook Regional Elementary School
Monument Valley Road, Great Barrington, MA

Indoor Air Results
Date: 11/4/2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
203 Art Room	17	73	34	669	ND	ND	16	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, lead pottery glaze.
204	2	73	32	472	ND	ND	11	Y # open: 0 # total: 1	Y ceiling	Y ceiling	Hallway DO, DEM.
205	18	73	31	449	ND	ND	10	Y # open: 2 # total: 2	Y wall	Y wall	Hallway DO, DEM, cleaners.
206	0	73	325	471	ND	ND	10	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM.
207	1	74	32	566	ND	ND	9	Y # open: 0 # total: 2	Y ceiling	Y ceiling	DEM.
208	18	74	35	692	ND	ND	15	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM.

ppm = parts per million

µg/m3 = micrograms per cubic meter

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CD = chalk dust

CP = ceiling plaster

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design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

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NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

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Muddy Brook Regional Elementary School
Monument Valley Road, Great Barrington, MA

Table 1

Indoor Air Results
Date: 11/4/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
209	2	74	32	532	ND	ND	8	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, DEM.
210	14	73	36	798	ND	ND	18	Y # open: 0 # total: 2	Y ceiling	Y ceiling	2 exhaust vents.
211	1	74	31	480	ND	ND	8	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, DEM.
212	16	73	38	821	ND	ND	13	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, DEM, pets.
213	7	73	33	664	ND	ND	11	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, DEM, UF.
214	23	72	39	797	ND	ND	15	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, DEM, plants, 2 vents.
221	0	70	40	485	ND	ND	10	N	Y ceiling	Y ceiling	Hallway DO,

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

VL = vent location

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Muddy Brook Regional Elementary School
Monument Valley Road, Great Barrington, MA

Table 1

Indoor Air Results
Date: 11/4/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
301	2	71	31	461	ND	ND	7	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM, flies.
302	2	72	30	464	ND	ND	9	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, flies.
305	1	71	30	396	ND	ND	8	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM, plants.
306	6	72	31	521	ND	ND	10	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM.
307	1	71	31	431	ND	ND	8	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, plant(s) on carpet, DEM, plants.
309	15	71	31	565	ND	ND	9	Y # open: 2 # total: 2	Y ceiling	Y ceiling	Hallway DO,

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									Supply	Exhaust	
311	18	71	33	565	ND	ND	11	Y # open: 0 # total: 2	Y ceiling	Y ceiling	DEM.
312	16	72	33	718	ND	ND	12	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, DEM, flies.
313	0	71	31	445	ND	ND	8	Y # open: 0 # total: 2	Y ceiling	Y ceiling	
314	20	71	36	717	ND	ND	13	Y # open: 1 # total: 2	Y ceiling	Y ceiling	DEM.

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